
Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Transportation Research Interdisciplinary Perspectives 8 (2020) 100141

Contents lists available at ScienceDirect

Transportation Research Interdisciplinary Perspectives

journal homepage: https://www.journals.elsevier.com/transportation-research-interdisciplinary-perspectives

# Modal share changes due to COVID-19: The case of Budapest

Péter Bucsky

*Doctoral School of Earth Sciences, University of Pécs, Pécs, Ifjúság útja 6, 7624, Hungary*

ARTICLE INFO

*Article history:*
Received 27 April 2020
Received in revised form 21 May 2020
Accepted 28 May 2020
Available online 12 June 2020

*Keywords:*
Public transport
Modal share
COVID-19
Cycling
Bike sharing
Road transport

ABSTRACT

The COVID-19 pandemic has had a rapid and significant impact on mobility. One of the most important responses of countries worldwide to slow the spread of the pandemic is to restrict the movement of people, which has had a considerable effect on transport systems. However, the reduction of transport is not identical for all modes of transport: public transport has seen the greatest decline so far. Understanding urban modal share developments during a pandemic situation can help cities better prepare for transport management in the future.



## 1. Introduction

The demand for urban transport is usually derived from economic output, population, migration, employment figures, schools, and various other factors (Holmgren, 2007). The choice between different modes of transport is influenced by fares, car ownership, service quality, salaries, etc. (Paulley et al., 2006), yet, in the event of a pandemic, these factors are adversely affected. The measures introduced by governments to reduce the spread of the virus are set to be in force for several months. During this period, the transport needs of cities have to be managed differently. Questions arise as to whether these changes will have a long-term effect, whether traffic patterns will simply follow former trends after the pandemic has ended, or whether some changes will remain.

Although there is currently no scientific evidence that the use of public transport represents a higher risk of infection with COVID-19, this has widely been assumed to be the case by governments, and policies have been designed to lower the use of its services. Data analysis for acute respiratory infection from the 2008/09 United Kingdom influenza season showed that the use of public transport resulted in a higher risk of being infected, but this difference was not statistically significant (Troko et al., 2011).

There is extensive literature available on factors influencing urban modal shares in cities (Santos et al., 2013), which include the fare system, how fuel prices influence the modal share of urban transport (Creutzig, 2014), ideal modal share in economic and environmental terms (Lohrey and Creutzig, 2016), the impact of climate change on urban transport (Banister, 2011), how to manage urban transport to control climate change (Sobrino and Monzon, 2013), and the challenges of growing the share of public and non-motorised transport (Batty et al., 2015). The actual or possible impact of pandemics, however, has not yet been researched.

The only comparable field of study is that of restriction of car usage in periods of high pollution (Farda and Balijepalli, 2018; Romero et al., 2019; Zhao and Yu, 2017). In periods when air pollution exceeds certain thresholds, motorised traffic is restricted. This can decrease transport demand and/or shift demand to public or non-motorised transport. However, the situation with pandemics is different: it is not that only one single mode of transport is restricted but also that demand for transport as a whole decreases. This may be the result of government restrictions on mobility and/or the result of fear of contamination, therefore, leading to reduced demand.

In the case of Budapest, the following mobility restrictions have been imposed since the first two COVID-19 cases were diagnosed on the 4th of March:

- The 11th of March: A state of national emergency is declared, universities are closed, indoor gatherings of more than 100 people and outdoor gatherings of more than 500 are prohibited.
- The 16th of March: All schools, pre-schools, and childcare facilities are closed.
- The 17th of March: Borders are closed for non-nationals with the exception of road freight transport drivers. All gatherings are prohibited, non-essential shops have to be closed by 3.00 p.m., and restaurants and cafes may only serve take-away food, beverages, and confectionery.
- The 27th of March: A limited curfew is introduced, people may leave home only for work, shopping, and jogging or going for a walk, but

*E-mail address:* peter.bucsky@gmail.com.

http://dx.doi.org/10.1016/j.trip.2020.100141

rules are not strict and are not enforced rigorously. Grocery stores may only serve senior citizens (aged 65 or over), and no one younger, between 9.00 and 12.00 a.m., and may not serve senior citizens at other times.

The effect of these measures was immediate: public opinion polls and Google's mobility report showed that mobility decreased severely and people stayed home (Ipsos, 2020a, 2020b; Google LLC, 2020).

The case of Budapest is especially interesting since it has one of the highest public transport modal shares in Europe with 45%, as only four European cities with a population of over 1 million had a higher share (EPOMM, 2020). The rate of motorisation (passenger cars per 1000 inhabitants) is low in comparison. In the European Union (EU) in 2018, it was 516 while in Budapest it was 376 according to Eurostat. Among major cities in the EU, only Vienna (with 374) and Berlin (with 330) had lower values. These figures illustrate the importance of public transport in the city.

## 2. Data and methods

There is no unified data collection for the different modes of transport in Budapest. Therefore, the particular modes will be analysed in the following sections. The research period is the month of March 2020: the changes made to patterns of transport by movement restrictions after the 16th of March present an opportunity to compare the two halves of the month.

Daily transport volumes by mode of transport were collected which serve the basis of the daily modal share calculations (Table 1). For road transport, automatic measured data was provided by Budapest Roads Ltd. (Budapest Közút Zrt., BK) and daily user statistics of route planner application Waze was collected. For public transport, the daily user numbers were calculated based on passenger countings of Budapest Centre for Transport Ltd. (Budapesti Közlekedési Központ Zrt., BKK) and it was apportioned by day based on Google's mobility report. The number of cyclists is available from 5 automatic measuring stations, while bike sharing system (BSS) usage data was provided by BKK. The daily usage data was compared with yearly modal split surveys and/or previous year measurement data.

The quality of data sources is very different. Good quality data is available for road transport, cycling, and bike sharing. The methodology of data collection for public transport is not described in sufficient detail by BKK: counting only occurred in one week and not on all lines, and only samples were used. Walking, however, presents the greatest problem: for this, only estimates can be made. Pedestrian transport is estimated in the modal split based on surveys conducted only yearly twice.

The data shows that road and public transport declined very sharply on the 16th and 17th of March parallel to the introduction of government restrictions. The level of mobility for these modes of transport was basically unchanged for the second half of the month. Cycling and BSS usage however saw an opposite trend: they started to grow after the introduction of mobility restrictions.

### 2.1. Road transport

The easiest and fastest way to acquire data on car usage in cities is the GPS base location data of smartphones and route planner applications. The number of active Waze users can be seen on the Wazestats.com website (Wazeststats, 2020).

BK, the public road management company of the city of Budapest, provided automatically collected data on all seven bridges linking the Buda and Pest sides of the city over the River Danube, which gives a fair representation of intra-city traffic in the capital. For measurement of commuter transport, the intersection of the M1 and M7 motorways is used. According to the yearly transport measurement from the latest available dataset from 2018, this road alone accounted for 15.6% of total traffic to and from the city of the total of 33 measured roads.

**Table 1**
Daily changes in transport volume in Budapest in March 2020 by mode of transport.

| Mode of transport | | Road traffic | | | Public transport | Bicycle | | BSS | |
|---|---|---|---|---|---|---|---|---|---|
| Data source | | BK - Danube bridges | BK - M1-M7 motorway | Wazestats | BKK | BKK/Eco Counter | | BKK | |
| Unit | | Vehicles/day | Vehicles/day | Users/day | Thousand passengers/day | Cyclists/day | Cyclists/day | Rentals/day | Rentals/day |
| Week | Day/year | 2020 | 2020 | 2020 | 2020 | 2020 | 2019 | 2020 | 2019 |
| Week 9 | 1 | 358,521 | 81,648 | 7957 | 2918 | 1528 | 2143 | 181 | 389 |
| Week 10 | 2 | 522,196 | 95,667 | 20,215 | 5042 | 2877 | 5010 | 462 | 750 |
| | 3 | 540,720 | 96,698 | 19,972 | 4910 | 2156 | 3900 | 329 | 729 |
| | 4 | 547,116 | 98,224 | 19,677 | 4910 | 2841 | 4338 | 419 | 747 |
| | 5 | 561,762 | 103,397 | 19,194 | 5108 | 3688 | 4212 | 525 | 784 |
| | 6 | 562,048 | 102,925 | 18,978 | 4778 | 1159 | 3875 | 193 | 786 |
| | 7 | 436,115 | 97,843 | 9785 | 2984 | 1954 | 3133 | 333 | 578 |
| | 8 | 369,326 | 84,031 | 9086 | 3067 | 2361 | 1703 | 325 | 292 |
| Week 11 | 9 | 516,382 | 96,270 | 20,323 | 4910 | 4146 | 3202 | 633 | 479 |
| | 10 | 528,977 | 99,046 | 19,677 | 5042 | 4846 | 4417 | 718 | 615 |
| | 11 | 541,392 | 99,789 | 19,892 | 4712 | 3533 | 3168 | 532 | 391 |
| | 12 | 542,519 | 103,919 | 17,312 | 4448 | 6689 | 3454 | 867 | 662 |
| | 13 | 519,329 | 103,350 | 13,548 | 3657 | 3571 | 1998 | 594 | 377 |
| | 14 | 331,383 | 77,697 | 7581 | 1905 | 3649 | 1614 | 437 | 367 |
| | 15 | 263,131 | 61,723 | 6075 | 1616 | 4211 | 7659 | 477 | 781 |
| Week 12 | 16 | 452,043 | 91,591 | 11,720 | 2338 | 5230 | 3601 | 858 | 658 |
| | 17 | 403,536 | 80,926 | 8602 | 1678 | 5945 | 4653 | 1292 | 738 |
| | 18 | 381,027 | 79,025 | 7581 | 1348 | 6792 | 5284 | 1526 | 872 |
| | 19 | 358,200 | 76,682 | 7151 | 1150 | 7192 | 5611 | 1707 | 926 |
| | 20 | 359,225 | 78,497 | 8226 | 1019 | 7876 | 6257 | 1797 | 1213 |
| | 21 | 212,809 | 45,892 | 4731 | 479 | 2839 | 7914 | 808 | 1026 |
| | 22 | 159,869 | 32,852 | 3212 | 277 | 1862 | 9264 | 615 | 1101 |
| Week 13 | 23 | 307,075 | 51,459 | 6041 | 359 | 1377 | 5097 | 272 | 934 |
| | 24 | 301,550 | 58,057 | 5496 | 425 | 2218 | 5032 | 543 | 822 |
| | 25 | 302,918 | 59,105 | 5324 | 359 | 1843 | 5868 | 455 | 965 |
| | 26 | 315,058 | 62,661 | 5335 | 491 | 3457 | 6290 | 766 | 986 |
| | 27 | 375,865 | 84,664 | 3455 | 821 | 6475 | 6887 | 1414 | 1128 |
| | 28 | 166,356 | 35,689 | 3212 | 287 | 7365 | 7528 | 1256 | 1327 |
| | 29 | 146,940 | 31,261 | 5513 | 277 | 7790 | 9615 | 1467 | 1174 |
| Week 14 | 30 | 286,486 | 56,111 | 5464 | 293 | 2280 | 7665 | 577 | 1215 |
| | 31 | 296,988 | 58,397 | 5410 | 425 | 3084 | 8360 | 754 | 1152 |

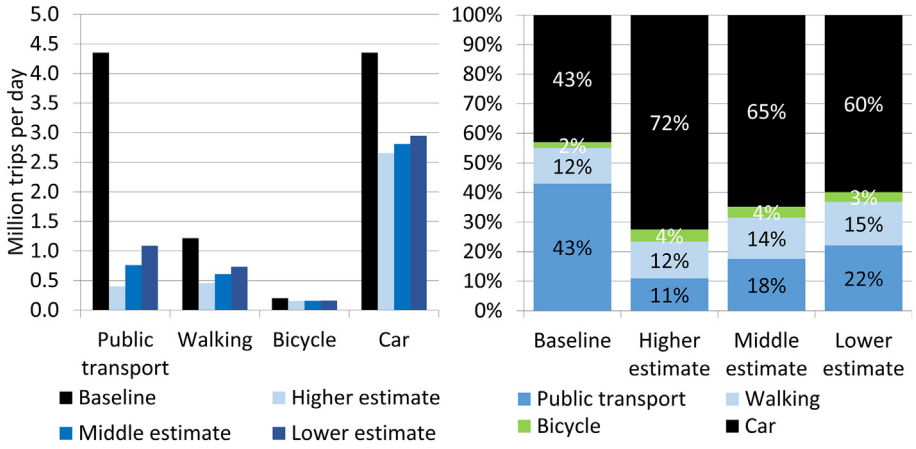


**Fig. 1.** Average trips by mode of transport and modal share in the second half of March 2020 compared with baseline in 2018.

By comparing the average traffic of weeks 10–11 with that of weeks 12–13, we can observe a drop of 37% on the Danube bridges and 34% on the M1–M7 motorways (Table 1). Waze users show a considerably higher drop of 61%. This illustrates the limitations of the use of application data on modelling traffic changes: as there were virtually no traffic jams after the 16th of March, the use of route planning applications became less important for drivers.

### 2.2. Public transport

Of all modes of transport, it was public transport on which the COVID-19 pandemic had the most direct effect. The decline in ridership has been evident since the beginning of the pandemic in Hungary. This change was not easy for the operator to foresee. This is illustrated by the frequent changes to schedules.

BKK has no electronic passenger counting; there is physical counting on approximately 100 locations and this is supplemented with household surveys (Mátrai et al., 2015). This is a lengthy process and cannot provide up-to-date information.

BKK started counting passengers physically in March 2020, e.g., by drivers and traffic controllers. The company shared their information on request and on the basis of their count reported a 90% drop in passenger number in week 13: instead of daily 4.3 million passengers, there were only 430 thousand (Table 1). Based on the daily changes in public transport use from Google location data, an estimate could be made of the daily shift in passenger numbers (Google LLC, 2020).

### 2.3. Pedestrian transport

There is no official data source available for pedestrian transport other than the survey-based yearly modal share report. Nonetheless, an estimation can be made with the aid of location data used by Google and public surveys (Google LLC, 2020; Ipsos, 2020b, 2020a). A daily survey of social connections and time spent away from home is filled online 364 thousand times and recorded by researchers. This shows a significant decrease in time spent away from home, dropping from 6.63 h on the 23th of March to 2.92 on the 31st of March (Rovó, 2020). Available mobility data sources and public opinion polls all show that in the second half of March, pedestrian traffic declined by around 50%.

### 2.4. Cycling

Cycling traffic is measured in five locations in Budapest, which gives a fair representation of the total traffic. As measurement of this mode of transport is very sensitive, with working days contrasting with weekends, one-month periods in different years cannot be compared according to exact dates: hence, the period of the 1st of March to the 31st of March 2020 was compared with that of the 3rd of March to the 2nd of April 2019, with the same numbers of working and weekdays thus falling within both periods.

In the second half of March, the level of cycling traffic stayed lower compared with that of preceding years despite active measures taken to encourage people to use their bicycles (Table 1). BKK introduced a further

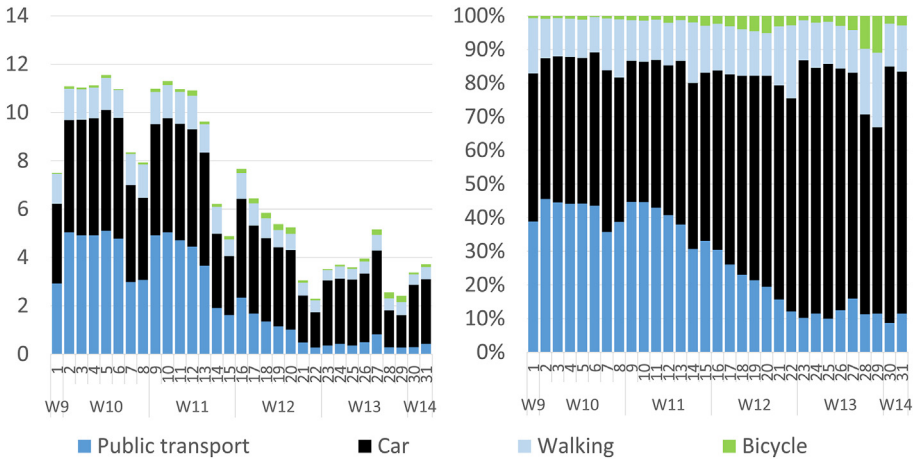


**Fig. 2.** Daily average trips by mode of transport and modal share by day in March 2020.

20 km of temporary bicycle lanes in the city centre in addition to the existing 256 km of cycle routes by reducing the number of lanes on some major roads (BKK, 2020).

### 2.5. Bike sharing system

Budapest introduced a docking station based BSS in 2014. Ridership of the service started to decline very rapidly. On the 17th of March, BKK introduced a new pricing system. Instead of the former 12,000 HUF/year (37 USD) subscription fee, a symbolic monthly fee of 100 HUF (0.3 USD) was introduced for an interim period during the crisis.

Despite generally declining levels of mobility, it had a rapid and direct effect on rentals: in week 12, rentals soared 151% above the average for weeks 10 and 11, but usage declined by 28% in week 13 (Table 1).

Compared with 2019, the new pricing had a positive effect on week 12, but this virtually disappeared the following week. BSS does not play any significant role in the transport volumes of the city, but the rapid reaction could attract attention to the system as a less risky mode of transport during a pandemic.

### 2.6. Further ridesharing systems

A handful of alternative mobility providers has been introduced in Budapest in recent years. Of these, some have mainly targeted tourists and have seen a higher impact. Only E-scooter rental companies Lime and Breezy have ceased operations. There are 1010 cars available from three car sharing companies. They saw a drop of 15—20% in the second half of March based on their statements, which have been provided on request.

## 3. Results

The most recent modal split data is available in the Budapest Mobility Plan 2030, which contains data for 2017 (City of Budapest, 2019). The modal share and transport volume was stable, so traffic data from 2017 has been used as a baseline to model the impact of transport restructuring during the crisis.

Three scenarios have been used to model transport in the second half of March 2020, more precisely in weeks 12 and 13. For pedestrian traffic, only an estimate of a 50% decline (with a margin of error of ±25% for higher and lower estimates) could be used for the modelling. For cars, public transport and cycling a margin of error of ±10% was used for higher and lower estimates.

Mobility was severely reduced, at least by 51% and maximally by 64%, and the middle estimate suggests a reduction of 57% in Budapest for the second half of March. The number of daily trips dropped from 10.1 to 4.3 million in the most likely scenario (Fig. 1).

Daily modelling for mobility changes for March 2020 was also possible. Data for walking is, however, not reliable. Measurement of time spent outside home and workplace was taken from Google. This indicates that the timeline for reduction in mobility differed by mode of transport. Despite the fact that no curfew was ordered until the 27th of March, the volume of transport reduced dramatically (Fig. 2). The introduction of the curfew, which has in fact been very limited, had no visible effect on the number of trips in March.

## 4. Discussion

Urban transport faces an unprecedented transformation due to the COVID-19 pandemic in a very short timeframe. There are positive trends like the growing popularity of cycling, but as the results show, the most important development in the modal split is the declining share of public transport and the substitution by road transport. The most important question is whether these changes are temporary or will they have long-term effects.

**Transit operators** will have to closely monitor not only their own ridership volumes but also modal split changes. The fear of contamination will most probably have a longer effect on mode of transport choice, therefore, they have to find new ways to make journeys less risky and gain public trust.

The presumably higher penetration of home office will reduce the demand for urban mobility. This can lead to reduced congestions in cities, which can make road transport more favourable for commuters. Lower ridership volumes will pose great financial burden for operators and will encourage the reduction of intervals and service quality. This can lead to a vicious circle of continuously declining ridership and quality.

Cities will have to examine new ways of making public transport attractive again: limiting road transport, introducing access charges, reducing the cost of public transport, or even introducing free services are among the options to be considered.

**Consumers** can expect growing competition and therefore lower prices for mobility. Shared mobility providers are already reducing fares and simplifying the usage of their vehicles.

Further research is needed to understand **longer term implications**. It is currently not possible to predict how long the fear of contagion will reduce demand for transport. It can be assumed that the longer the mobility restrictions will be in force, the longer these effects will last. The spread of working from home and online shopping can both reduce mobility demand also in the long run which will have a major impact on urban mobility and modal share.

## 5. Conclusions

The COVID-19 pandemic and the restrictions introduced more than half of transport demands in the city of Budapest almost immediately after the introduction of mobility restrictions. Traffic volumes stabilised at this lower volume, and further restrictions on movement had no significant effect. However, reduction levels differed greatly among the various modes of transport. Public transport experienced so far the greatest reduction in demand (80%), while cycling and bike sharing saw the lowest decrease (23% and 2%, respectively).

In the modal share, however, cycling could account for the highest growth. In March 2020, it held a 4% share, which is more than double the 2% share it held in 2018. The most important development in March 2020 during the pandemic was the unprecedented growth of car usage in the modal share from 43% to 65%. Meanwhile, the share of public transport decreased from 43% to 18% only.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## References

Banister, D., 2011. Cities, mobility and climate change. J. Transp. Geogr. 19, 1538–1546. https://doi.org/10.1016/j.jtrangeo.2011.03.009.

Batty, P., Palacin, R., González-Gil, A., 2015. Challenges and opportunities in developing urban modal shift. Travel Behav. Soc. 2, 109–123. https://doi.org/10.1016/j.tbs.2014.12.001.

BKK, 2020. Temporary Bicycle Lanes are Supporting Transport During the Pandemic (in Hungarian: Ideiglenes kerékpársávok segítik a közlekedést járvány idején) [WWW Document]. Cent. Budapest Transp URL. https://bkk.hu/2020/04/ideiglenes-kerekparsavok-segitik-kozlekedest-jarvany-idejen/.

City of Budapest, 2019. Budapest mobility plan 2030 – V. Monitoring and evaluating manual (in Hungarian: Budapesti Mobilitási Terv 2030 - V. Monitoring és értékelési kézikünyv) [WWW document]. URL. https://budapest.hu/Documents/BudapestiMobilitásiTerv2030/V_BMT_Monitoring_értékelési_kézikönyv_20190114[1].pdf.

Creutzig, F., 2014. How fuel prices determine public transport infrastructure, modal shares and urban form. Urban Clim. 10, 63–76. https://doi.org/10.1016/j.uclim.2014.09.003.

EPOMM, 2020. TEMS - the EPOMM Modal Split Tool [WWW document]. URL. http://www.epomm.eu/tems/result_cities.phtml?more=1. (Accessed 7 March 2020).

Farda, M., Balijepalli, C., 2018. Exploring the effectiveness of demand management policy in reducing traffic congestion and environmental pollution: car-free day and odd-even plate measures for Bandung city in Indonesia. Case Stud. Transp. Policy 6, 577–590. https://doi.org/10.1016/j.cstp.2018.07.008.

Google LLC, 2020. Google COVID-19 community mobility reports [WWW document]. URL. https://www.google.com/covid19/mobility. (Accessed 25 April 2020).

Holmgren, J., 2007. Meta-analysis of public transport demand. Transp. Res. Part A Policy Pract. 41, 1021–1035. https://doi.org/10.1016/j.tra.2007.06.003.

Ipsos, 2020a. Hungarians Take Risks of Coronavirus Seriously and are Careful (in Hungarian: Komolyan Veszik a koronavírus kockázatait, és óvatosak a magyarok) [WWW Document]. Ipsos URL. https://www.ipsos.com/hu-hu/komolyan-veszik-koronavirus-kockazatait-es-ovatosak-magyarok. (Accessed 13 April 2020).

Ipsos, 2020b. The First Week Survey is Avaliable on the Crisis Research Series From Multiple Angle (in Hungarian: Elérhet ő a válság hatásait fogyasztói szempontból vizsgáló kutatássorozat els ő heti riportja) [WWW Document]. Ipsos URL. https://www.ipsos.com/hu-hu/elerheto-valsag-hatasait-fogyasztoi-szempontbol-vizsgalo-kutatassorozat-elso-heti-riportja. (Accessed 9 April 2020).

Lohrey, S., Creutzig, F., 2016. A 'sustainability window' of urban form. Transp. Res. Part D Transp. Environ. 45, 96–111. https://doi.org/10.1016/j.trd.2015.09.004.

Mátrai, T., Ábel, M., Kerényi, L.S., 2015. How can a transport model be integrated to the strategic transport planning approach: a case study from Budapest. 2015 Int. Conf. Model. Technol. Intell. Transp. Syst. MT-ITS 2015 , pp. 192–199. https://doi.org/10.1109/MTITS.2015.7223256.

Paulley, N., Balcombe, R., Mackett, R., Titheridge, H., Preston, J., Wardman, M., Shires, J., White, P., 2006. The demand for public transport: the effects of fares, quality of service, income and car ownership. Transp. Policy 13, 295–306. https://doi.org/10.1016/j.tranpol.2005.12.004.

Romero, F., Gomez, J., Rangel, T., Vassallo, J.M., 2019. Impact of restrictions to tackle high pollution episodes in Madrid: modal share change in commuting corridors. Transp. Res. Part D Transp. Environ. 77, 77–91. https://doi.org/10.1016/j.trd.2019.10.021.

Rovó, L., 2020. With Population Data to Control the Coronavirus (in Hungarian: Lakossági adatokkal a koronavírus megfékezéséért) [WWW Document]. Univ. Szeged URL. https://covid.sed.hu/tabs/stats. (Accessed 25 April 2020).

Santos, G., Maoh, H., Potoglou, D., von Brunn, T., 2013. Factors influencing modal split of commuting journeys in medium-size European cities. J. Transp. Geogr. 30, 127–137. https://doi.org/10.1016/j.jtrangeo.2013.04.005.

Sobrino, N., Monzon, A., 2013. Management of urban mobility to control climate change in cities in Spain. Transp. Res. Rec. 55–61. https://doi.org/10.3141/2375-07.

Troko, J., Myles, P., Gibson, J., Hashim, A., Enstone, J., Kingdon, S., Packham, C., Amin, S., Hayward, A., Van-Tam, J.N., 2011. Is public transport a risk factor for acute respiratory infection? BMC Infect. Dis. 11, 2–7. https://doi.org/10.1186/1471-2334-11-16.

Wazeststats, 2020. Active Wazers in HU Budapest [WWW document]. URL. http://wazestats.com/active.php?city=7. (Accessed 10 April 2020).

Zhao, S., Yu, Y., 2017. Effect of short-term regional traffic restriction on urban submicron particulate pollution. J. Environ. Sci. (China) 55, 86–99. https://doi.org/10.1016/j.jes.2016.06.023.